

[0209] Another aspect is digitization of object shapes. There are times that one would like to take a plastic model or a real world part as a starting point for a 3D design. Prior art devices that capture 3D shapes are however, expensive and cumbersome and cannot, like the invention, share their function for replacement of the mouse or 2D graphic tablet.

[0210] We propose one single inexpensive device that can give all of this control and also act as a drawing pad, or input a 3D sculptured forms or even allow the user to use real clay that as she sculptures it the computer records the new shape.

[0211] The invention as here disclosed relates physical activities and physical objects directly to computer instructions. A novice user can design a house with a collection of targeted model or "toy" doors, windows, walls etc. By touching the appropriate toy component and then moving and rotating the user's hand she can place the component at the appropriate position. The user can either get his or her visual cue by looking at the position of the toy on the desk or by watching the corresponding scaled view on the computer display. Many other embodiments are also possible.

[0212] **FIG. 2a**

[0213] This figure illustrates an embodiment wherein the invention is used to "work" on an object, as opposed to pointing or otherwise indicating commands or actions. It is a computer aided design system (CAD) embodiment according to the invention which illustrates several basic principles of optically aided computer inputs using single or dual/multi-camera (Stereo) photogrammetry. Illustrated are new forms of inputs to effect both the design and simulated assembly of objects.

[0214] 3D Computer Aided Design (CAD) was one of the first areas to bump up against the need for new 3D input and control capability. A mouse or in the alternative, as 2D graphic tablet, together with software that displays several different views of the design are the current standard method. The drawback is that you are forced to move along 2D planes defined by display views or what are known as construction views of the design object.

[0215] This situation is especially frustrating when you start creating a design from scratch. The more sculptured the design, the more difficult this becomes. The current CAD experience feels more like an astronaut in a space suit with bulky fingertips and limited visibility trying to do delicate surgery.

[0216] A large number of specialized input devices have been designed to handle some of these problems but have had limited success. Just remember your own frustrations with the standard mouse. Imagine attempting to precisely and rapidly define and control complex 3D shapes all day, every day. This limits the usefulness of such design tools to only a relatively rare group, and not the population as a whole.

[0217] Ideally we want to return to the world we experience everyday where we simply reach our hand to select what we want to work with, turn it to examine it more closely, move and rotate it to a proper position to attach it to another object, find the right location and orientation to apply a bend of the proper amount and orientation to allow it to fit around another design object, capture 3D real work models, or stretch and sculpture designs.

[0218] One of the most wonderful properties of this invention is that it gives the user the ability to control not only 3D location with the motion of his hand but he also has 4 other pieces of data (3 orientation angles and time) that can be applied to control parameters. For example if we wanted to blend 2 designs (say a Ferrari and a Corvette) to create a new design, this process could be controlled simply by

[0219] 1) moving the users hand from left to right to define the location of the cross section to be blended,

[0220] 2) tilt the hand forward to defined the percentage "P" used to blend the 2 cross sections, and

[0221] 3) hit the letter R on the keyboard to record items 1 and 2. From the each of the 2 cross sectional curves define a set of (x, y) coordinates and create a blended cross sectional coordinate set as follows:

$$X(\text{blend}) = P * X(\text{Ferrari}) + (1 - P) * X(\text{Corvette})$$

$$Y(\text{blend}) = P * Y(\text{Ferrari}) + (1 - P) * Y(\text{Corvette})$$

[0222] Note here and elsewhere, keystrokes can be replace if desired by voice commands, assuming suitable voice recognition capability in the computer

[0223] In the apparatus of **FIG. 1**, we desire to use a touching and indicating device **216** with action tip **217** and multidegree of freedom enabling target **215** that the user holds in her hand. Single targets, or multiple targets can be used with a camera system such as **206** so as to provide up to 6 axis information of pointing device position and orientation vis a vis the camera reference frame, and by matrix transform, to any other coordinate system such as that of a TV display, **220**

[0224] In using the invention in the form, a user can send an interrupt signal from an "interrupt member" (such as pressing a keyboard key) to capture a single target location and orientation or a stream of target locations (ended with another interrupt). A computer program in computer determines the location and orientation of the target. The location and orientation of the "action tip": **217** of the pointing device can be computed with simple offset calculations from the location and orientation of the target or target set.

[0225] The set of tip **217** locations defines the 3D shape of the real world object **205**. Different targeted tools with long or curved extensions to their action tips can be used to reach around the real world object while maintaining an attached target in the target volume so the cameras can record its location/orientation.

[0226] By lifting the tip of the pointing device off the surface of the object, the user can send location and orientation information to operate a computer program that will deform or modify the shape of the computer model displayed. Note that the user can deform a computer model even if there is no real world object under the tip. The tip location and orientation can always be passed to the computer program that is deforming the computer model.

[0227] The same device can be used to replace graphic tablets, mice, or white boards, or to be used in conjunction with a display screen, turning into a form of touch screen (as previously, and further discussed herein). In one mode Interrupt members can be activated (i.e. a button or keyboard key etc. can be pressed) like mouse buttons. These together with the target ID can initiate a computer program